

Hookworms of Bobcats (*Felis rufus*) from Florida

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ABSTRACT: From 1974 to 1991, 85 bobcats (*Felis rufus* Schreber) from 17 counties in Florida were examined at necropsy for hookworms. At least 1 of 4 species of *Ancylostoma* was found in 52/85 (61%) bobcats. *Ancylostoma tubaeforme* (Zeder, 1800), *A. caninum* (Ercolani, 1859), *A. braziliense* (de Faria, 1910), and *A. pluridentatum* (Alessandrini, 1905) were represented at prevalences of 11, 18, 19, and 29%, respectively. Intensities for all hookworms combined varied from 1 to 128 (\bar{x} = 17.6, SD = 28.6) with mixed infections (2 or more species) in 20 (24%) bobcats. Significantly more infected juveniles (8/10) than adults (12/35) had mixed infections (χ^2 = 5.06, 1 df, P < 0.025). Prevalences and intensities for all species combined did not differ significantly between sexes, ages, and regions with the exception of mean intensity of infection, which was much greater in the southern (\bar{x} = 25.3) than in the northern (\bar{x} = 6.3) region (P < 0.01). *Ancylostoma pluridentatum* was found only in bobcats from southern Florida, where its prevalence was 57%. *Ancylostoma caninum*, *A. tubaeforme*, and *A. braziliense* were distributed throughout the state.

KEY WORDS: bobcat, *Felis rufus*, hookworms, *Ancylostoma* spp., Florida, prevalence, intensity.

The parasites of bobcats, *Felis rufus*, have been studied in various localities in the United States (Rollings, 1945; Pollack, 1949; Progulske, 1952; Miller and Harkema, 1968; Little et al., 1971; Mitchell and Beasom, 1974; Stone and Pence, 1978; Watson et al., 1981; Fox, 1983; Tiekotter, 1985; Marchiondo et al., 1986; Heidt et al., 1988; Mensik-King, 1989). Little information has been published on the parasitic fauna of bobcats in Florida with the exception of data presented in Forrester et al. (1985) and Forrester (1992). In both references the presence of *Ancylostoma pluridentatum* in bobcats of southern Florida was discussed.

Hookworms can be highly pathogenic in domestic dogs and cats, causing rough hair coat, listlessness, weakness, poor weight gain and emaciation, edema, anemia, and death, especially in young animals (Miller, 1965, 1966; Onwuliri et al., 1981; Kalkofen, 1987). Because the bobcat is distributed throughout Florida, it may serve as a reservoir of hookworms for domestic as well as other wild carnivores such as the endangered Florida panther (*Felis concolor coryi* Bangs). The

purposes of this study were to determine the species of hookworms present, their prevalence, intensity, and distribution in bobcats of Florida, and locality-, sex-, or age-related differences in those parameters.

Materials and Methods

From 1974 to 1991 bobcats were obtained as road-kills, by trapping, or by hunting from 17 counties in Florida (Fig. 1). Counties from Tampa Bay north (A–I: Leon, Wakulla, Columbia, Baker, Alachua, Levy, Flagler, Lake, and Polk) were designated as northern; those south of Tampa Bay (J–Q: Sarasota, Highlands, Glades, Lee, Hendry, Palm Beach, Collier, and Dade) were classified as southern. Carcasses were frozen until necropsy. Ages of bobcats (adult or juvenile) were based on dentition and/or size. Recovery, fixation, and preservation of helminths followed Kinsella and Forrester (1972), with the small intestine divided into sections for ease of handling. Hookworms were mounted and cleared in lactophenol or phenol–alcohol for identification and counting. Confirmation of species was impossible in some cases due to damaged or immature specimens or the inability to distinguish females of *A. tubaeforme* from *A. caninum*. Hookworms from bobcats in the previously mentioned Florida studies were reexamined for this project. The data were analyzed using the SAS system (SAS Institute, 1988) for prevalence (PROC FREQ CHISQ) and intensity (reported as mean [SD]) (PROC NPARIWAY WILCOXON) of the hookworm species found in each region, sex, and age class. Representative specimens have been deposited in the U.S. National Parasite Collection, Beltsville, Maryland (USNM Helm. Coll. Nos. 82292–82298).

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Results and Discussion

Eighty-five bobcats, 41 from northern and 44 from southern Florida, were included in this study. Thirty were collected in 1979, 25 in 1985, 17 from 1986 to 1988; the remaining years were represented by 3 or fewer samples. There were 26 females (6 juveniles, 20 adults) and 59 males (8 juveniles, 51 adults). At least 1 of 4 species of *Ancylostoma* was found in 52/85 (61%) bobcats. In 7 bobcats, identification of all specimens could not be determined for the reasons already noted; females of *A. tubaeforme* and *A. caninum* from all bobcats were combined for analysis. Intensities varied from 1 to 128 ($\bar{x} = 17.6$ [26.8]). Prevalences of *A. tubaeforme*, *A. caninum*, *A. braziliense*, and *A. pluridentatum* were 11, 18, 19, and 29%, respectively. The prevalence and intensity for each species of hookworm are listed in Table 1. Mixed infections (2 or more species) were seen in 20 (24%) animals. Six others had males of either *A. tubaeforme* or *A. caninum*, and females of 1 or both. Significantly more infected juveniles (8/10) than adults (12/35) had mixed infections ($\chi^2 = 4.86$, 1 df, $P < 0.05$). This could reflect increasing immunity to hookworms with age (Miller, 1965, 1966; Stone and Pence, 1978; Watson et al., 1981) or transmammary transmission. With data for all species combined, there were no differences in intensities or prevalences between the 2 age classes or sexes of hosts, nor in prevalences between northern and southern cats. However, mean intensity for all species combined varied significantly between regions (Wilcoxon $Z = 2.89$, $P < 0.01$), with northern bobcats infected with an average of 6.2 (7.7) and southern animals with 25.3 (32.1) hookworms.

While *A. tubaeforme*, *A. caninum*, and *A. braziliense* were found statewide, *A. pluridentatum* was present only in southern Florida, in Highlands, Lee, Hendry, Collier, and Dade counties.

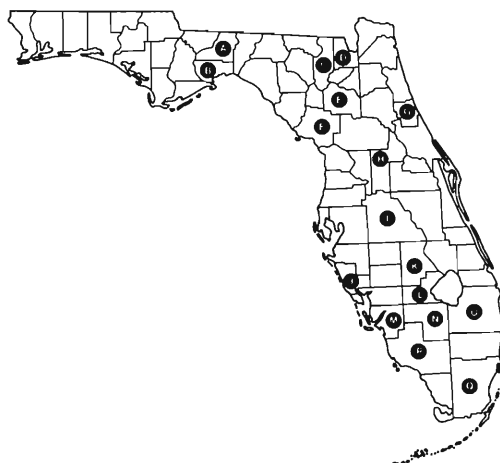


Figure 1. Collection areas for bobcats in Florida, with number collected from each county: (A) Leon (1); (B) Wakulla (5); (C) Columbia (5); (D) Baker (5); (E) Alachua (9); (F) Levy (11); (G) Flagler (1); (H) Lake (1); (I) Polk (3); (J) Sarasota (2); (K) Highlands (4); (L) Glades (2); (M) Lee (4); (N) Hendry (6); (O) Palm Beach (1); (P) Collier (21); (Q) Dade (4).

In that area, the prevalence of *A. pluridentatum* was 57% ($\chi^2 = 33.00$, $P < 0.001$) with a mean intensity of 28.6 (34.2). Prevalences and intensities for each species on a regional basis are given in Table 2. While the intensities for the other species did not vary between north and south, the prevalence of *A. braziliense* was greater in the northern region ($\chi^2 = 4.41$, $P < 0.05$).

The distribution of *A. tubaeforme*, *A. caninum*, and *A. braziliense* throughout the state suggests that the bobcat may serve as a reservoir of hookworm infections for other wild and domestic carnivores. Conti (1984) found all 3 species in the gray fox (*Urocyon cinereoargenteus*) of Florida, and they have been identified in samples from Florida panthers (McLaughlin and Forrester, un-

Table 1. Hookworms of 85 bobcats from 17 counties in Florida, 1974–1991.

Species of <i>Ancylostoma</i>	USNM Coll. No.	Prevalence		Intensity			Distribution*
		N	(%)	\bar{x}	SD	Range	
<i>A. tubaeforme</i> †	82295–6	9	(11)	1.9	0.78	1–3	E–I, M, P, Q
<i>A. caninum</i> †	82294	15	(18)	2.6	3.44	1–14	A–C, E, F, H, K, M, N, P, Q
<i>A. braziliense</i>	82297–8	16	(19)	4.1	3.52	1–12	B, D, E, F, I, J, M, P
<i>A. pluridentatum</i>	82292–3	25	(29)	28.6	34.2	1–128	K, M, N, P, Q
<i>Ancylostoma</i> spp.‡		24	(28)	3.2	3.63	1–16	A–K, M, N, P, Q

* Letters refer to counties in Figure 1.

† Includes only males.

‡ Includes females of *A. tubaeforme* and *A. caninum*, damaged and immature specimens.

Table 2. Prevalence and intensity of hookworms of 85 Florida bobcats by region. Values with the same letter do not differ significantly ($\alpha = 0.05$) for that species.

Species	Prevalence		Intensity	
	North	South	North	South
	N (%)	N (%)	\bar{x} (SD)	\bar{x} (SD)
<i>Ancylostoma tubaeforme</i> *	4 (10) ^a	5 (11) ^a	2.0 (0.82) ^a	1.8 (0.84) ^a
<i>Ancylostoma caninum</i> *	7 (17) ^a	8 (18) ^a	3.9 (4.78) ^a	1.5 (1.07) ^a
<i>Ancylostoma braziliense</i>	12 (29) ^a	4 (9) ^b	3.9 (3.15) ^a	4.8 (4.99) ^a
<i>Ancylostoma pluridentatum</i>	0 (0) ^a	25 (57) ^b	0 ^a	28.6 (34.2) ^b
<i>Ancylostoma</i> spp.†	15 (37) ^a	9 (20) ^a	3.3 (3.99) ^a	3.2 (3.15) ^a

* Includes only males.

† Includes females of *A. tubaeforme* and *A. caninum*, damaged and immature specimens.

publ. data). *Ancylostoma caninum* has been found in red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), and black bears (*Ursus americanus*), and *A. tubaeforme* is known from red foxes in Florida (Crum, 1977; Conti, 1984). These hookworms are found also in domestic cats (*Felis catus*) and dogs (*Canis familiaris*) in Florida (Greiner et al., 1992; McLaughlin and Forrester, unpubl. data).

The presence of *A. pluridentatum* in Florida felids (Forrester et al., 1985) is intriguing because it has been found previously only in wild felids and domestic cats in or from Central and South America (Schwartz, 1927; Thatcher, 1971; See-see et al., 1981; Moriena, 1983). O'Brien et al. (1990) presented genetic evidence of a recent introduction (~35 yr ago) of pumas of South or Central American origin into southern Florida. *Ancylostoma pluridentatum* may have been introduced at the same time. Its ability to infect panthers, bobcats, and domestic cats increases its potential distribution in Florida, while also augmenting the environmental egg burden. There have been no studies to determine the environmental factors limiting the range of this parasite, either in Latin America or in Florida. Also, with the exception of a preliminary study on 3 domestic kittens summarized by Forrester (1992), no information is available regarding the pathogenicity of *A. pluridentatum* to any felid species. In that study, clinical signs were noted with infections of fewer than 250 *A. pluridentatum*. Until more data are collected, it is not possible to assess the potential impact of this parasite on the endangered Florida panther, on the Florida bobcat population, on wild felids in Central and South America, or on domestic cats.

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Literature Cited

- Conti, J. A. 1984. Helminths of foxes and coyotes in Florida. Proceedings of the Helminthological Society of Washington 51:365-367.
- Crum, J. M. 1977. Some parasites of black bears (*Ursus americanus*) in the southeastern United States. M.S. Thesis, University of Georgia, Athens. 76 pp.
- Forrester, D. J. 1992. Parasites and Diseases of Wild Mammals in Florida. University Press of Florida, Gainesville. 459 pp.
- , J. A. Conti, and R. C. Belden. 1985. Parasites of the Florida panther (*Felis concolor coryi*). Proceedings of the Helminthological Society of Washington 52:95-97.
- Fox, J. S. 1983. Relationships of diseases and parasites to the distribution and abundance of bobcats in New York. Ph.D. Dissertation, State University of New York, Syracuse. 101 pp.
- Greiner, E. C., D. G. Brenner, D. D. Cox, and D. L. Heaton-Jones. 1992. Comparison of febantel tablets and Vercom® paste against gastrointestinal nematodes of dogs. Veterinary Parasitology 41: 151-156.
- Heidt, G. A., R. A. Rucker, M. L. Kennedy, and M. E. Baeyens. 1988. Hematology, intestinal parasites, and selected disease antibodies from a population

- of bobcats (*Felis rufus*) in central Arkansas. *Journal of Wildlife Diseases* 24:180–183.
- Kalkofen, U. P.** 1987. Hookworms of dogs and cats. *Veterinary Clinics of North America: Small Animal Practice* 17:1341–1354.
- Kinsella, J. M., and D. J. Forrester.** 1972. Helminths of the Florida duck, *Anas platyrhynchos fulvigula*. *Proceedings of the Helminthological Society of Washington* 39:173–176.
- Little, J. W., J. P. Smith, F. F. Knowlton, and R. R. Bell.** 1971. Incidence and geographic distribution of some nematodes in Texas bobcats. *Texas Journal of Science* 22:403–407.
- Marchiondo, A. A., J. F. Karpowitz, and G. A. Conder.** 1986. Parasites of the bobcat (*Lynx rufus pallascens*) in central and southern Utah. *Proceedings of the Helminthological Society of Washington* 53:113–116.
- Mensik-King, K. E.** 1989. Helminth parasites in bobcats (*Felis rufus*) of Jackson county, Oregon. M.S. Thesis, Humboldt State University, Arcata, California. 63 pp.
- Miller, G. C., and R. Harkema.** 1968. Helminths of some wild mammals in the southeastern United States. *Proceedings of the Helminthological Society of Washington* 35:118–125.
- Miller, T. A.** 1965. Influence of age and sex on the susceptibility of dogs to primary infection with *Ancylostoma caninum*. *Journal of Parasitology* 51:701–704.
- . 1966. Blood loss during hookworm infection, determined by erythrocyte labeling with radioactive ⁵¹chromium. II. Pathogenesis of *Ancylostoma braziliense* infection in dogs and cats. *Journal of Parasitology* 52:856–865.
- Mitchell, R. L., and S. L. Beasom.** 1974. Hookworms in south Texas coyotes and bobcats. *Journal of Wildlife Management* 38:455–458.
- Moriena, R. A.** 1983. A report from Argentina of *Ancylostoma pluriidentatum* in *Felis concolor*. *Revista de Medicina Veterinaria* 64:184–188.
- O'Brien, S. J., M. E. Roelke, N. Yuhki, K. W. Richards, W. E. Johnson, W. L. Franklin, A. E. Anderson, O. L. Bass, Jr., R. C. Belden, and J. S. Martenson.** 1990. Genetic introgression within the Florida panther (*Felis concolor coryi*). *National Geographic Research* 6:485–494.
- Onwuliri, C. O. E., A. B. C. Nwosu, and A. O. Anya.** 1981. Experimental *Ancylostoma tubaeforme* infection of cats: Changes in blood values and worm burden in relation to single infections of varying size. *Zeitschrift für Parasitenkunde* 64:149–155.
- Pollack, E. M.** 1949. Ecology of the bobcat (*Lynx rufus rufus* Schreber) in the New England states. M.S. Thesis, University of Massachusetts, Amherst. 120 pp.
- Progulske, D. R.** 1952. The bobcat and its relationship to prey species in Virginia. M.S. Thesis, Virginia Polytechnic Institute, Blacksburg. 135 pp.
- Rollings, C. T.** 1945. Habits, foods, and parasites of the bobcat in Minnesota. *Journal of Wildlife Management* 9:131–145.
- SAS Institute.** 1988. SAS/STAT® User's Guide, Release 6.03 Edition. SAS Institute Inc., Cary, North Carolina. 1028 pp.
- Schwartz, B.** 1927. Description of *Ancylostoma pluriidentatum*, hookworm of carnivores, and a review of the genus *Ancylostoma*. *Proceedings of the United States National Museum* 72:1–9.
- Seesee, F. M., D. E. Worley, and R. L. Martin.** 1981. A survey of nematode parasites from carnivores of the Chaco Boreal, Paraguay. Pages 846–858 in *Worldwide Furbearer Conference Proceedings*, 3–11 August 1980.
- Stone, J. E., and D. B. Pence.** 1978. Ecology of helminth parasitism in the bobcat from west Texas. *Journal of Parasitology* 64:295–302.
- Thatcher, V. E.** 1971. Some hookworms of the genus *Ancylostoma* from Colombia and Panama. *Proceedings of the Helminthological Society of Washington* 38:109–116.
- Tiekotter, K. L.** 1985. Helminth species diversity and biology in the bobcat, *Lynx rufus* (Schreber), from Nebraska. *Journal of Parasitology* 71:227–234.
- Watson, T. G., V. F. Nettles, and W. R. Davidson.** 1981. Endoparasites and selected infectious agents in bobcats (*Felis rufus*) from West Virginia and Georgia. *Journal of Wildlife Diseases* 17:547–554.